PARAMETER REFINEMENT FOR HABITAT CAPABILITY MODELS FOR THE ROCKY MOUNTAINS

Final Report

Parameter refinement for habitat capability models for the Rocky Mountains

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INTRODUCTION

Habitat capability models (HABCAP) are used to predict wildlife responses to existing or proposed future habitat conditions (U.S.D.A. Forest Service 1990), and are based on empirically-demonstrated or expert opinions of wildlife responses to vegetation, particularly to structural stages for various tree dominants. Not every vertebrate species for which HABCAP models are desired has been studied in every structural stage of every tree dominant, so the empirical basis for HABCAP varies among animal species, tree dominants, and structural stages. It is, of course, desirable that models accurately reflect species responses to habitat conditions, and be revised to reflect new information when it becomes available, however, the means to do that are not straightforward.

The objective of this study was to apply new empirical data on four species of small mammal (southern red-backed vole [*Clethrionomys gapperi*], deer mouse [*Peromyscus maniculatus*], masked shrew [*Sorex cinereus*], red squirrel [*Tamiasciurus hudsonicus*]) to the HABCAP coefficients used in U.S. Forest Service Region 2 for these species. The empirical data were proposed to originate from two sources:

1. small mammal habitat studies conducted at the Coon Creek study area, Wyoming, from 1985 to 1996

2. other habitat studies of the species of interest in or near Region 2 that have been completed since HABCAP coefficients for these species were originally developed.

We summarize the methods used in the Coon Creek small mammal study and the results of that study specific to structural stages present in the Coon Creek study area, and review literature for the species of interest for Region 2, or areas nearby. The revision of existing model coefficients based on empirical data results in changes to the average

coefficient for all structural stages, which can affect the apparent overall habitat value of the area being modeled. Therefore, we discuss these changes and the potential problems that result from them, and propose a method for dealing with this problem that may be applied to future, similar applications of new data to HABCAP coefficients. Lastly, the use of data sets collected over time periods that differ among structural stages raises additional problems in modifying existing HABCAP coefficients.

Current Models

Currently, the HABCAP coefficients for species of interest are those given by U.S.D.A. Forest Service (1990) (Tables 1-8). No HABCAP coefficients are presented by U.S.D.A. Forest Service (1990) for red squirrels in high-elevation riparian, or for masked shrews in any cover type.

METHODS

Development of Coefficients from Empirical Data

Coefficients for mammals in the Rocky Mountains were originally derived from expert-opinion-based rankings of habitat quality by structural stage initially published in Towry (1984), and modified in U.S.D.A. Forest Service (1990). For all species, the habitat quality values are given by Towry (1984) as either 1 (highest quality), 2 (intermediate quality), 5 (low quality) or blank (no habitat value). These have been converted to HABCAP coefficients (U.S.D.A. Forest Service 1990) by calculating the reciprocal of the first three coefficients, and using zero for the last. So, 1 becomes a

coefficient of 1/1 = 1 (optimal habitat), 2 becomes ½ = 0.5 (intermediate quality habitat), 5 becomes 1/5 = 0.2 (low quality habitat), and 0 remains 0 (zero habitat value).

These initial coefficients can be revised using empirical data using the approach described by Rumble et al. (1999, in litt.). The steps in this process are essentially as follows:

1. Determine proportional use by structural stage. For the empirical data, determine the proportions of use or observations that occur in each of the structural stages of interest. For example, if three structural stages, L4b, L4c, and S5 were considered, then the proportions would appear as shown in Table 9. The proportions should total 1.0.

2. Test for a difference between empirical data and existing HABCAP coefficient. Conduct an inferential test of whether these observations reject or fail to reject the proportions hypothesized by the existing HABCAP coefficients for the species of interest in the structural stages of interest (Table 10). For example, a 95% confidence interval (CI) can be constructed around the empirical data, and then the hypothesized value (existing HABCAP coefficient) compared with the CI. If all HABCAP coefficients for that species fall within the CI, then one would fail to reject the existing HABCAP coefficients as a reliable indicator of habitat quality. The existing HABCAP coefficient would be retained as valid. If, on the other hand, the existing HABCAP model coefficient falls outside the CI, then one would reject the existing HABCAP coefficient as a reliable indicator of habitat capability and proceed with the next step, revision of the HABCAP coefficient. Importantly, the protocol described in this step assumes that empirical data are available for the full set of structural stages present in existing model.

If empirical data are available for only a subset of structural stages, then a new set of problems presents itself; these are discussed below.

3. Revision of the HABCAP coefficient. For each structural stage, multiply the proportional use times the "total habitat value," the sum of the existing HABCAP coefficients (total of existing HABCAP coefficients [1.7] in Table 10). This new set of values reflects the redistribution of habitat value held in the structural stages represented in the new data empirical data. If the highest habitat value or values exceed one (for example structural stage L4b [1.19] in Table 10), then all HABCAP coefficients are adjusted by the reciprocal of the highest HABCAP coefficient (coefficients in the case of a tie) (1/1.19 in the case of L4b in Table 10), so that the highest coefficient is now 1, and the others are scaled to it in linear proportion. These revised HABCAP coefficients are now compared with the empirical data again, using an inferential test (step 2, above). The coefficients are iteratively revised and tested against the empirical data until the coefficients for all structural stages fall within the respective CI around the empirical data. In some cases, these iterative revisions may not result in HABCAP coefficients that are within the CI's around the empirical data. In such cases, a subjective resetting of one value so that it falls within the empirically based CI's may be necessary.

The Effect of Revision of Coefficients on Average Habitat Value

The above procedure, if it includes a downward adjustment in the highest HABCAP coefficient to a value of 1, results in a reduction in the apparent average habitat value, as indicated by the mean (or total) of the HABCAP coefficients across structural stages (1.7 vs. 1.43, Table 10). If HABCAP coefficients were revised, based on empirical data, after

the original coefficients were applied to a specific area of land, then the revised coefficients could result in an apparent decline in habitat value of the area as predicted by HABCAP, even though no habitat changes had taken place. In other words, the reallocation of habitat value to various structural stages, based on empirical data, can result in an apparent net loss of habitat value for an area of land as a artifact of the process used to revise the HABCAP coefficients. This is likely to occur where, in the empirical data, the structural stage with the highest proportional use is more strongly preferred than was recognized in the original coefficients. The opposite effect – an increase in the apparent average habitat value across all structural stages as a result of a uniform distribution of structural-stage-specific coefficients – does not occur. Therefore, revision of HABCAP coefficients with empirical data has a tendency to "ratchet" the apparent average habitat value (or, the sum of all coefficients for all structural stages) downward, if empirical data show that a species prefers the most preferred structural stage more than was reflected in the original HABCAP coefficients. This poses a problem in the consistent application of HABCAP over long time intervals, during which new empirical data become available and are used to revise coefficients for a subset of all those available.

Development of Coefficients for this Project

Revision of existing coefficients -- We revised coefficients for those species dominant – structural stage combinations for which data were available using the methods described above, based on the approach of Rumble (1999, in litt.). Because the structural stages present at Coon Creek represented a subset of those for which coefficients have been

modeled for the region (U.S.D.A. Forest Service 1990), we used the following approach for revising those coefficients affected by Coon Creek data. We summed the coefficients for the structural stages for which data were available. Using the hypothetical example in Table 11, assume that we have available new data only for structural stages 4c and 5, but no new data for structural stage 4b. We would reallocate the summed coefficients for 4c and 5 (= 0.7) to be proportional to the new data. The resulting coefficients reflect the relationships between the coefficients for which we have empirical data, but leave the other coefficient (that for 5b) and the sum of all coefficients (1.7) unchanged. No inferential test was conducted to compare the original coefficients with the new data, because of different durations of study among structural stages.

Development of new coefficients -- For species – structural stage permutations for which coefficients are not currently available, we used the following approach to develop them. We hypothesized equal proportional use of the structural stages studied at Coon Creek; these became the original coefficients against the observational data were tested, following the method described in steps 1-3 above. (Table 12)

The Coon Creek Small Mammal Study

The Coon Creek small mammal study was intiated to understand responses of small mammals to intensive patch cutting in subalpine Rocky Mountain forests. The patch cutting was conducted for the primary purpose of investigating the effect of this silvicultural practice on water run-off. However, the opportunity presented by this experiment was used to learn how small mammals responded to this perturbation. Here,

we use part of the Coon Creek data to examine relative use of various structural stages, using the patch cuts employed at Coon Creek to represent an early structural stage.

Literature review

A number of studies have been conducted of small mammal habitat association or habitat selection in Region 2 and adjacent areas since HABCAP was developed in 1990 (U.S.D.A. Forest Service 1990). These include a number of studies of the species considered here, and summarized in Appendix A. The major problems in applying these data to the HABCAP coefficients for Region 2 are:

1. The dissimilarity between vegetation types. Deer mice, for example, have been studied in a wide range of vegetation types, in the intermountain west, of which a relative few were identified structural stages of species dominants for which HABCAP coefficients are reported by U. S. Forest Service (1990).

2. Lack of information on structural stages and canopy cover. To apply the data to HABCAP, the published accounts must have species dominant, structural stage, and for pole-sapling and mature stages, canopy cover. This information is not provided for any of the primary literature summarized in Appendix A. stage criteria to be able to be used to modify HABCAP coefficients.

3. Where data have gathered on structural stages relevant to Region 2, a small subset of the structural stages for which coefficients are calculated are represented in the studies.

Adjusting the coefficients of a subset of the structural stages has the effect of "ratcheting down" the overall habitat value of a species dominant, as explained above.

As a result of these limitations, it appears impossible to use the literature summarized in Appendix A to modify the HABCAP coefficients.

Study area and methods

Field studies were conducted on two adjacent watersheds in the Sierra Madre Mountains of southern Wyoming (41° 3'N, 106° 44'W, Fig. 1) (Raphael 1988). The climate features brief, cool summers and cold, snowy winters. Total annual precipitation is about 1000 mm, about 70% falling as snow, and mean yearly maximum snow depth, typically in March, for the study period (1985-96) was 1980 mm. Mean snow depth during May for the period was 1280 mm. Vegetation was dominated by lodgepole pine (70% of area) on drier sites and a mixture of Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*) on moister, especially riparian sites.

Within the 985-ha Coon Creek (CC) watershed, the treatment area (908 ha) received 240 patch cuts of mean area 1.5 ha (range: 0.1-7.0 ha) and a system of connecting roads (total length = 31.5 km). The 908-ha East Fork of the Encampment River (EF) watershed served as an uncut (< 0.2% of area was cut) control with no roads before or after cutting. The two watersheds were similar in vegetative and physical structure. Before cutting, both sides had about 3.2% of their areas in natural openings; after cutting, an additional 25.5% of the treatment area had been cut.

Small mammal sampling -- Small mammal and habitat sampling were conducted at 180 plots, 90 in each of the two watersheds. These plots were spaced at 200-m intervals on north-south transects spaced 400 m apart (Fig. 1). Considering three treatment categories of the 180 plots, control area ($n = 90$), cut sites in treatment area ($n = 45$), and adjacent sites in treatment area ($n = 45$), the three major cover types (lodgepole pine, spruce - fir, wet meadow) were distributed independently of the treatment categories ($\chi^2 = 5.1$, df = 4, $P = 0.28$). The same was not true for structural stages, however; pole (80 - 230 mm dbh) stages were cut more and mature stages (dbh > 230 mm) less than expected, considering their availability ($\chi^2 = 30.4$, df = 4, $P < 0.001$). This apparently resulted from the avoidance, under environmental regulations, of cutting in riparian sites, which tend to hold larger trees than upland sites.

To facilitate comparisons between watersheds and among years, we conducted small mammal trapping during the same time each year (ca. 20 July - 25 August), at the same time on control and treatment areas (similar numbers of traps on treatment and control areas on a given night), and by rotating field workers among trap lines and experimental areas within a year. We placed 6 pitfall traps, each an 11.4-L plastic bucket in a 2×3 array, at 15-m intervals, centered on the sampling plot. Each pit was buried with its rim flush with the ground. Within 2 m of each pitfall, a 200-mm Sherman live trap was placed on the first and last night of each trapping session, and two such traps on nights 2 - 9 of the trapping session. Traps were baited with rolled oats and provided with polyester bedding material. Thus, each station received 120 trap-nights and 60 pit-nights of sampling effort each year, so that total small mammal sampling effort for the study was 259,200 trap nights and 129,600 pit nights. All captured animals were identified to

species. Each animal was marked at first capture, with the marks being unique to a year, so that previously captured animals could be identified. All analyses, then, involved numbers of individual animals per plot per year.

Red squirrels were sampled during standardized bird surveys conducted early each summer, distributing sampling effort across control and treatment areas on a given day. An observer walked to the center of a sampling plot, waited for 1 min, then listened for red squirrel calls and watched for red squirrels for 10 min, attempting to identify individual squirrels by their position within that period. When detected, the horizontal distance from the observer to the squirrel was estimated, up to a distance of 100 m. All red squirrels within 100 m of the sampling plot were included in the count.

Statistical Analyses

Because sampling took place at plots that were separated by at least 200 m, several times larger than the home range diameters of the species studied (southern red-backed vole: 0.01 - 0.5 ha [Merritt and Merritt 1978]), we considered the plots to be units of replication, although a few movements of marked individuals among plots were observed. All data analyses were conducted using Excel and SPSS version 9.

RESULTS

The structural stages present on the Coon Creek study area are shown in Table 13. Two sources of information were available: the structural stage classifications derived from RIS data for stands developed by the Medicine Bow National Forest, and data developed from attributes of the small mammal trapping plots themselves. The

agreement between these data sets was not strong. When nine structural stages were considered, the number of plots for which the RIS and trapping plot classifications of structural stage were concordant was 49 (28%) of the 173 plots for which both data sets contained values. When only five structural stages were considered (Table 13), the concordance between the two systems was 50% (86 of 173 plots). Because of varying amounts of cutting on the patch cuts, some of the discordance falls in the structural stage 1 categories. By excluding all plots classified in either data set as structural stage 1, the concordance was increased to 60% (73 of 121 plots of structural stage ≥ 2). Because the values based on conditions at the trapping plots more accurately represent the environments to which small mammal abundances responded, we used them in our calculations of HABCAP coefficients. We calculated proportional use of n species-dominant – structural stage combinations present on the Coon Creek study area (Tables 14-15). Importantly, the number of years represented for the recently patch-cut sites (L1 and S1, 4 years) differs from that for later structural stages (12 years), because the post-cutting period (1993-96) was a subset of the entire study period. So, it was not possible to directly compare the relative number of "occurrences," for a species between structural stage 1 and later structural stages. It is straightforward to calculate proportional use expressed as animals captured per plot per year, but the sampling units disappear from such a metric, so that inferential procedures, as used by Rumble (in litt.) are not possible. It would be possible to include only the post-cutting years for all sampling plots, but that would ignore 2/3 of the Coon Creek data, and would emphasize the post-cutting period, when the control watershed a might exhibit some effects of cutting.

Recalculation of model coefficients

DISCUSSION

It is not possible, with currently available approaches, to apply the data on small mammal abundances in various structural stages of various tree dominants at Coon Creek to the revision of HABCAP coefficients. This is so for several reasons:

1. The method proposed by Rumble (in litt.) assumes that the full set of structural stages (1-9) for which coefficients are available are represented in the new data. This is not the case for Coon Creek, for which some structural stages are missing.

2. The poor correspondence between structural stage classifications of the trapping plots at Coon Creek, as determined by RIS data versus data developed at the scale of the trapping plots themselves. It would seem appropriate to use the RIS classifications, because these stand-level designations are those for which RIS was originally intended, however conditions at the trapping plots in most cases differ from the nominal stand type, which argues for the use of the smaller-scale trapping plot data. This lack of concordance occurred using only scale 1-5. Use of scale the scale of 1-9 (incorporating canopy cover data) would have reduced the concordance further.

3. For structural stages 3, 4, and 6 in spruce-fir – dominated stands, only one trapping plot was sampled for each structural stage, which results in an estimate with a much higher degree of sampling error than is the case for some other structural stages (e.g. stage 8 lodgpole pine, n = 16 plots). The Coon Creek small mammal study was designed to produce representative estimates of small mammal populations in the two watersheds, rather than to provide estimates of small mammal abundance in the full range of

structural stages present in the two watersheds, with comparable sampling errors among structural stages.

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U.S.D.A. Forest Service. 1990. HABCAP Habitat capability model, Rocky Mountain Region: documentation and users guide. U.S.D.A. Forest Service, Rocky Mountain Region, Lakewood, Colorado.

Table 1. Current HABCAP coefficients for the southern red-backed vole in high-elevation riparian forest in Region 2 (U.S.D.A. Forest Service 1990). Notations for structural stages are those of Towry (1984) followed in parentheses by those used by U.S.D.A. Forest Service (1990).

	Structural stages								
Type of use	1 (1)	2 (2)	3a (3)	3b (4)	3c (5)	4a (6)	4b (7)	4c (8)	5 (9)
Feeding	0	0	0.5	0.5	0.5	1	1	1	1
Cover	0	0	0.5	0.5	0.5	1	1	1	1

Table 2. Current HABCAP coefficients for the southern red-backed vole in lodgepole pine forest in Region 2 (U.S.D.A. Forest Service 1990). Notations for structural stages are those of Towry (1984) followed in parentheses by those used by U.S.D.A. Forest Service (1990).

	Structural stages								
Type of use	1 (1)	2 (2)	3a (3)	3b (4)	3c (5)	4a (6)	4b (7)	4c (8)	5 (9)
Feeding	0	0	0.2	0.2	0.2	1	1	1	1
Cover	0	0	0.2	0.2	0.2	1	1	1	1

Table 3. Current HABCAP coefficients for the southern red-backed vole in spruce-fir forest in Region 2 (U.S.D.A. Forest Service 1990). Notations for structural stages are those of Towry (1984) followed in parentheses by those used by U.S.D.A. Forest Service (1990).

	Structural stages								
Type of use	1 (1)	2 (2)	3a (3)	3b (4)	3c (5)	4a (6)	4b (7)	4c (8)	5 (9)
Feeding	0	0	0.5	0.5	0.5	1	1	1	1
Cover	0	0	0.5	0.5	0.5	1	1	1	1

Table 4. Current HABCAP coefficients for the deer mouse in high-elevation riparian forest in Region 2 (U.S.D.A. Forest Service 1990). Notations for structural stages are those of Towry (1984) followed in parentheses by those used by U.S.D.A. Forest Service (1990).

	Structural stages								
Type of use	1 (1)	2 (2)	3a (3)	3b (4)	3c (5)	4a (6)	4b (7)	4c (8)	5 (9)
Feeding	0.5	1	1	1	0.5	0.5	0.5	0.5	0.5
Cover	0.5	1	1	1	0.5	0.5	0.5	0.5	0.5

Table 5. Current HABCAP coefficients for the deer mouse in lodgepole pine forest in Region 2 (U.S.D.A. Forest Service 1990). Notations for structural stages are those of Towry (1984) followed in parentheses by those used by U.S.D.A. Forest Service (1990).

	Structural stages								
Type of use	1 (1)	2 (2)	3a (3)	3b (4)	3c (5)	4a (6)	4b (7)	4c (8)	5 (9)
Feeding	0.5	1	1	0.5	0.2	0.5	0.5	0.2	0.2
Cover	0.5	1	1	0.5	0.2	0.5	0.5	0.2	0.2

Table 6. Current HABCAP coefficients for the deer mouse in spruce-fir forest in Region 2 (U.S.D.A. Forest Service 1990). Notations for structural stages are those of Towry (1984) followed in parentheses by those used by U.S.D.A. Forest Service (1990).

	Structural stages								
Type of use	1 (1)	2 (2)	3a (3)	3b (4)	3c (5)	4a (6)	4b (7)	4c (8)	5 (9)
Feeding	0.5	1	1	0.5	0.2	0.5	0.5	0.2	0.2
Cover	0.5	1	1	0.5	0.2	0.5	0.5	0.2	0.2

Table 7. Current HABCAP coefficients for the red squirrel in lodgepole pine forest in Region 2 (U.S.D.A. Forest Service 1990). Notations for structural stages are those of Towry (1984) followed in parentheses by those used by U.S.D.A. Forest Service (1990).

	Structural stages								
Type of use	1 (1)	2 (2)	3a (3)	3b (4)	3c (5)	4a (6)	4b (7)	4c (8)	5 (9)
Feeding	0.5	0.5	0.5	0.5	0.5	0.5	1	1	1
Cover	0.5	0.5	0.5	0.5	0.5	0.5	1	1	1

Table 8. Current HABCAP coefficients for the red squirrel in spruce-fir forest in Region 2 (U.S.D.A. Forest Service 1990). Notations for structural stages are those of Towry (1984) followed in parentheses by those used by U.S.D.A. Forest Service (1990).

	Structural stages								
Type of use	1 (1)	2 (2)	3a (3)	3b (4)	3c (5)	4a (6)	4b (7)	4c (8)	5 (9)
Feeding	0.5	0.5	0.5	1	1	1	1	1	1
Cover	0.5	0.5	0.5	1	1	1	1	1	1

Table 9. Hypothetical proportional uses of three structural stages.

Structural stage	Observations	Proportion of use
4b	70	0.7
4c	20	0.2
5	10	0.1
Total	100	1.0

Table 10. Hypothetical inferential test of proportional use of three structural stages against original habitat capability model (HABCAP) coefficients, and revision of coefficients because of a rejection of the no-difference hypothesis.

Structural stage	Observations	Proportion of use	Original HABCAP coefficients	First revision of HABCAP coefficients	Second revision of HABCAP coefficients
4b	70	0.7	1	0.7 x 1.7 = 1.19	1.19 x 1/1.19 = 1
4c	20	0.2	0.5	0.2 x 1.7 = 0.34	0.34 x 1/1.19 = 0.29
5	10	0.1	0.2	0.1 x 1.7 = 0.17	0.17 x 1/1.19 = 0.14
Total	100	1.0	1.7		1.43

Table 11. Hypothetical revision of original habitat capability model (HABCAP) coefficients where data are available on a subset of three structural stages. The example assumes that data are available for structural stages 4c and 5, but not 4b. In this case, no inferential test for a difference between observed and expected (original) values is possible because of the absence of data for one structural stage.

Structural stage	Original coefficients	Observations	Revised coefficients (rounded)
4b	1	no data	1
4c	0.5	30	0.23 (0.2)
5	0.2	60	0.47 (0.5)
Total	1.7	90	1.7 (1.7)

Table 12. Hypothetical creation of habitat capability model (HABCAP) coefficients for a single species dominant, where no coefficients have been reported before. The hypothesized proportional use for each structural stage is 1/s, where s = number of structural stages present for that species dominant, in this case 3.

Structural stage	Original coefficients	Assumed propor-tional use	Observations	Proportion of observations	CI around proportion
4b	none	0.33	140	0.38	0.30 – 0.46
4c	none	0.33	63	0.17	0.14 – 0.21
5	none	0.33	166	0.45	0.36 – 0.54
Total		1	369	1	

Table 13. Classification of structural stages (on a scale of 1-5) of small mammal trapping plots at the Coon Creek study area from two data sources, the RIS stand-level data generated by the Medicine Bow National Forest, and structural stage designations derived from conditions at the trapping plots themselves. The total number of plots classified is 167, less than the 180 plots on the study area, because of missing values for some plots.

	Trapping plot data				
RIS data	1	3	4	5	Totals
1	13	6	9	0	28
3	1	7	13	0	21
4	17	17	66	18	118
5	0	0	0	0	0

Table 14. Proportional use of various structural stages (on a scale of 1-9) of lodgepole-pine dominated stands present at the Coon Creek study area for three species of small mammal. The number of observations (animals caught) cannot be compared directly between structural stages, because of different sampling effort (number of years of sampling) between structural stages.

Structural stage	*n* (plots)	*n* (years)	*Clethrionomys gapperi*	*Peromyscus maniculatus*	*Sorex cinereus*
			Animals/ plot yr	Animals/ plot yr	Animals/ plot yr
1	11	4*	0.86	2.18	0.77
4	5	12	2.85	2.8	0.45
6	4	12	2.04	1.8	0.31
7	8	12	2.20	1.45	0.59
8	16	12	2.36	1.26	0.45
9	3	12	4.69	0.86	0.75

* 1993-96, the period during which patch cuts were present.

Table 15. Proportional use of various structural stages of spruce-fir dominated stands present at the Coon Creek study area for three species of small mammal. The number of observations (animals caught) cannot be compared directly between structural stages, because of different sampling effort (number of years of sampling) between structural stages.

Structural stage	*n* (plots)	*n* (years)	*Clethrionomys gapperi*	*Peromyscus maniculatus*	*Sorex cinereus*
			Animals/ plot yr	Animals/ plot yr	Animals/ plot yr
1	9	4*	2	1.69	1.25
3	1	12	4.25	2.08	0.25
4	1	12	2.5	2.83	0.25
6	1	12	8.83	0.83	1.42
8	3	12	6.92	1.17	1.08
9	3	12	6.36	0.56	0.97

* 1993-96, the period during which patch cuts were present.

Appendix A. Primary literature that reports, and secondary literature that reviews small mammal habitat associations or habitat selection in and near U.S. Forest Service Region 2, 1990-present.

Southern red-backed vole (*Clethrionomys gapperi*)

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